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Seeking the Optimal Dimension of Local Administrative Units: A Reflection on Urban Concentration and Changes in Municipal Size

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Abstract: In the search for a better administrative functioning as a key dimension of economic performances, changes in municipal boundaries and the creation (or suppression) of local administrative units reflect a progressive adjustment to a spatially varying population size and density. With intense population growth, municipal size reflects the overall amount (and spatial concentration) of services and infrastructures, being functionally related with agglomeration economies, land availability for building, and specific sociodemographic attributes of local communities. Based on these premises, the intrinsic relationship between settlement expansion, population growth, and municipal size in a metropolitan region of Southern Europe (Attica, hosting the Greater Athens' area in Central Greece) was investigated in this study over nearly one century as a contribution to a refined investigation of the (changing) organization of local administrative units under a complete metropolitan cycle from urbanization to reurbanization. Based on descriptive statistics, mapping, (parametric and nonparametric) correlation coefficients, and econometric techniques, a quantitative analysis of the relationship between population size and density and municipal area provides pivotal knowledge to policy and planning adjustments toward a more balanced spatial distribution of population and administered land among local government units. Together with a slight decrease in the average municipal size over time, the average population density per municipal unit increased systematically, with a considerable reduction in spatial heterogeneity of settlements. The observed goodness-of-fit of the linear model explaining municipal area with population density, increased significantly over time. Empirical results of our study indicate that municipal size has slowly adjusted to population density across metropolitan areas, determining an imbalanced spatial distribution of resident population and a supposedly less efficient government partition. The recent administrative reform of local authorities in Greece (the so-called 'Kallikratis' law) seems to consolidate–rather than rebalance this organizational structure over space, reflecting spatially polarized settlements. Such conditions represent a base for informed analysis of the spatial structure of local administrative units as a pivotal element of economic sustainability and may contribute to the debate on the optimal size of municipalities at both urban and metropolitan scales of governance.

Keywords: local governance; administrative reforms; regional studies; optimal size; Mediterranean; Europe

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1. Introduction

Given the emphasis on policy making of administrative units, the emergent notion of the 'optimal size' of local governments has stimulated an articulated debate among academics [1–3], that has frequently taken geographical, economic, political and social differences into account [4–8]. The spatial organization of local authorities was demonstrated to exert a relevant impact on administrative performances, e.g., in terms of costs

of governmental services perceived by users [9–11]. This aspect concerns the possibility to define an optimal size of municipalities (and generally for cities), considering the relationship among the level of urbanization, agglomeration factors, and economic development at large [12]. The notion of 'optimal size' of local authorities—and, more specifically, municipalities—was therefore based on the economic rationality that should guide country and regional governments in the provision of basic public infrastructure and services [13–15].

Changes in municipal boundaries and the creation (or suppression) of local administrative units are important measures allowing for a better administrative performance [16]. However, earlier studies have provided some mixed results as far as the abovementioned relationship is concerned, since municipal size may affect the administrative capacity of providing services and answering the (changing) needs of resident populations through several mechanisms (such as economies of scale and agglomeration) possibly exploiting positive externalities, both economic and noneconomic [17]. Empirical evidence of the importance of scale economies due to municipal amalgamations has been documented extensively [18,19] as long as municipalities do not overcome a critical dimension [13,20,21]; other studies highlight the importance of agglomeration economies [22–24]. Less economic efficiency than the what was expected [25], or even the existence of diseconomies of scale in the case of municipal mergers, have also been reported [26].

Diseconomies of scale associated with larger government units—requiring proportionally more administration efforts and resources—are another relevant issue in political science under socially fragmented territories and increasing competitiveness among local contexts [27–29]. Studying these issues would suggest not imposing constraints on for example, city size, although the increase of resident population in small municipalities may generate negative effects of congestion, thus leading to impose some limitations on the expansion of these spatial aggregates [30]. Furthermore, with optimal jurisdiction size being a cornerstone in government design, a long-established tradition in political thought focuses on integrated economic and noneconomic issues, concluding that democracy and governance efficiency thrive in smaller administrative units [31]. A minor research stream has focused on the economic effects of intermunicipal cooperation [32,33] in specific fields and services, e.g., waste collection [34–36].

Literature reviews and results from empirical works have concordantly argued how all these arguments did not derive from an effective and solid empirical base [37]. When evaluating the impact of jurisdiction size on various socioeconomic criteria, ambiguous results emerged due to several reasons, including sorting effects, ambiguous definition of governance units, data endogeneity, and the lack of dedicated experiments simulating the impact of policy reforms [38]. Evidence is almost narrow in terms of methodologies and techniques, and often focused on single economic sectors [39]. As a contribution to this deserving issue, our study assumes transformations in municipal boundaries with creation (or suppression) of new administrative units as a progressive adjustment toward a more balanced distribution of population over space [40], possibly impacting governance efficiency and, broadly speaking, economic sustainability [41]. Since municipal size is a relevant variable reflecting the amount of services and infrastructures—possibly related to both population concentration and land availability for building in expanding metropolitan regions [42–44]—a quantitative analysis of the relationship between population density and the municipal area is assumed to provide appropriate knowledge contributing to the identification of 'optimal' local units, as far as the administered population is concerned and intended as a proxy of services' aggregated demand.

More specifically, the present study investigates and discusses the relationship between urban expansion, economic agglomeration, population density, and municipal size, in a metropolitan region of Southern Europe (Attica, hosting Athens, the Greek capital city) between 1928 and 2021, using population census data and other official statistics [45]. This time period encompassed a complete city life cycle from urbanization to reurbanization and reflects a rapid, but spatially and temporally heterogeneous, settlement growth. The main

aim of the study is twofold: first, to discuss the notion of the 'optimal government size' in the study area, representative of marginal economic contexts of Mediterranean Europe and, second, to evaluate the possible impact of demographic and settlement changes on the average size of local administrative units (namely municipalities) evaluating a sufficiently long time interval covering important socioeconomic transformations in the country [44]. The recent administrative reform of local authorities in Greece (the so-called 'Kallikratis' law) provides additional hints for a comparative analysis of the spatial structure of local administrative units. Taken as a prerequisite for economic sustainability, such (heterogeneous) experimental conditions characteristic of the study area, may depict broader socioeconomic contexts in Southern Europe. The empirical results of descriptive statistics, mapping, correlation coefficients, and simplified econometric models adopting linear specifications were used to support our discussion, assuming municipal size exerts a direct (or, at least, indirect) impact on both urban and metropolitan governance. The present study is organized as follows: an extensive literature review is provided in Section 2, with a specific rationale focusing on the relationship between municipal size and population concentration. Section 3 provides a broad description of the empirical exercise presented in this study: Section 3.1 identifies the main characteristics of the study area; Section 3.2 delineates the logical framework at the base of the empirical exercise based on data sources; elementary variables are presented in Section 3.3; and statistical (econometric) approaches are presented in Section 3.4. Section 4 analytically describes the empirical findings of this study and Section 5 extensively debates the relationship between population density and municipal size over both time and space. Section 6 concludes the study with some specific policy recommendations and planning suggestions and indications for future research.

2. Literature

In the last decades, municipal amalgamation has accounted for a substantial reduction of the number of councils in several countries worldwide [27,46–48]. Theoretical frameworks and empirical approaches supporting programs of municipal consolidation argue that important economic benefits will flow from fewer and larger municipal councils. Based on the Australian experience in the 1990s—where amalgamation programs resulted in an evident decrease of the number of local administrative units—[40] tested the hypothesis that larger municipalities would exhibit greater economic efficiency. However, a growing skepticism in policy circles over the efficacy of municipal consolidation as a suitable method of enhancing the operational efficiency of local councils was reported, e.g., for Australia [49].

Apart from large amalgamation programs, a range of promising alternative options was proposed "that may be able to effectively combine more efficient service delivery with vibrant local democracy" [50]. Carruthers and Ulfarsson [42] investigated the relationship between governmental fragmentation and local development, outlining the emergent need to promote jurisdictional cooperation and regulatory consistency across regions. Unique systems of highly decentralized municipalities were historically promoted and maintained over time in Northern Europe [51] and an extensive discussion about merging municipalities has emerged, for instance, in Denmark [52].

Keil and Boudreau [47] highlighted the role of social movement demands in the revision of municipal government mechanisms in Canada. Steiner [46] found that "reform-friendly authorities, intensive social contacts among the inhabitants of the municipalities, a favorable topographic location and the policies of the superordinate government level promote enthusiasm for reforms". Lassen and Serritzlew [28] found different results from a quasi-experiment based on a large-scale municipal reform in Denmark, that allowed estimating a causal effect of an administrative unit's size on internal political efficacy. Empirical results from the study indicated how "jurisdiction size has a causal and sizeable detrimental effect on citizens' internal political efficacy".

In other words, as suggested by Rose [53], the effect of size "is not merely a by-product of the compositional characteristics of the individual living in different sized

municipalities", suggesting that municipal size seems also to be neutral in term of citizens' interest in (and knowledge of) local politics [54]. However, while it is reasonable to expect size to be relevant, the nature of the relationship may vary from one form of participation to another [55]. In Norway, central government has recently designed a framework to consolidate municipalities based on a voluntary program. Based on this context, [56] tested if political transaction costs would hinder associations, analyzing some efficiency and cost proposition built on spatiotemporal data for Norwegian local authorities [57]. Reforms, especially those affecting a partial ensemble of municipalities in a given region, often result in exogenous and substantial changes in municipal population size with uncertain impacts on governance efficiency [58].

By analyzing the provision of local government services in monetary terms (i.e., evaluating the costs' structure), Carey et al. [59] operationalized the concept of an 'optimal' size for administrative units of different governance level (e.g., regional authorities prefectures, provinces, homogeneous districts with specific administrative duties, and municipalities). Based on empirical models, the optimal number of municipalities for a fixed population size in a given regional context was identified under the assumption that geographic aggregation of local units into larger and denser districts would reduce costs of public services (Figure 1). The provision of local services such as water delivery, waste management, or sewerage collection, just to mention some of the most relevant contributions to local development toward a truly sustainable path [60], normally require the existence of scale and agglomeration economies. The same applies to the production of utilities by physical infrastructures that have to balance the related costs [10].

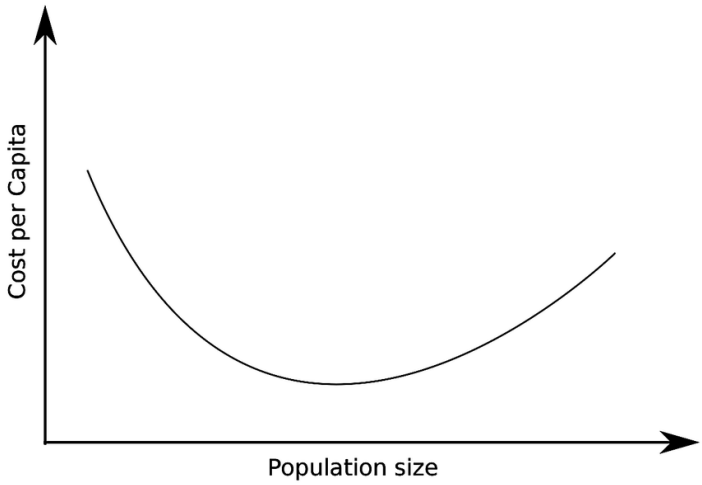

Figure 1. The assumed relationship between population size and (per-capita) management cost of local governance units, following mainstream literature as cited in the extensive bibliographic review in Section 2 (Source: Authors' own elaboration).

Although policymakers usually believe that larger municipalities may exhibit greater (i) economic performances (i.e., lower costs), (ii) social efficiency (e.g., the ability to completely satisfy the demand of both quantitative and qualitative terms), and (iii) environmental sustainability (e.g., the capacity to fulfil the requested environmental targets in territorial management, mainly as a by-product of socioeconomic development), evidence is mixed about the relationship between population density and municipal size [57] as far as the three dimensions above are concerned. While larger municipalities with populations over 250,000 are supposed to be less efficient using many different evaluation criteria, a weak correlation between size and efficiency was observed for municipalities with populations between 25,000 and 250,000 inhabitants [61]. Moreover, while literature suggests that smaller municipalities are likely to be less efficient and perform worse, important deviations from this general pattern have been documented [59]. At the same

time, small municipalities have been frequently demonstrated to be largely efficient (both quantitatively and qualitatively) in the provision of specialized services [31].

Assuming that local public governments have to provide several public goods and services, the quantification of the 'optimal size' of a given administrative unit can be markedly divergent, when based on different types of public goods and services [62]. With this perspective in mind, Blom-Hansen et al. [63] argued that the issue of 'optimal size' of jurisdiction is ephemeral, since there are 'multiple' optimal sizes, depending on the specific dimension considered. By highlighting the importance of fulfilling the needs of small groups of residents [64], the idea is coherent with those suggested by Oates [65] who concludes that a rational administrative partition should be based on three principles: (i) large regional administrations that recognize a joint use of public goods and environmental resources, (ii) small local governments providing goods and services according to the specific need of local communities, and (iii) metropolitan jurisdictions extending over the areas inhabited by people benefiting from public goods provided by the cities [32].

Some scholars have also argued that population size is suboptimal as a proxy of municipal output as local government areas with similar population sizes can have different economic, demographic, topographical, and spatial characteristics [54,66]. Buljan et al. [55] found other important determinants of per-capita expenditures in local units as well, such as population density and other socioeconomic factors. For instance, quantitative analyses have demonstrated that residential density differs from one advanced country, city, and time to another [2]. In this line of thinking, Bernardelli et al. [1] found a strong correlation between municipal expenditures and population density and argued that population size may have an impact on municipal expenditure in response to (largely unpredictable) variations in population density.

An extensive and low-density urban morphology has negative effects on the cost efficiency of providing some public services, e.g., when it comes to basic infrastructure [67,68]. A U-shaped relationship exists between the local public (per-capita) expenditures and population density and the cost savings might be more attainable when population density increases [69,70]. On the one hand, a denser residential area means that residents are located closer, which may cause negative consequences from both social welfare and environmental sustainability perspectives [42]. On the other hand, a more compact residential area pushes firms to locate closer to that zone, in order to reduce the costs of transport and other logistical activities, which is positive from a socioeconomic point of view [2].

Kasanko et al. [71] showed that the intrinsic structure of European cities has become less compact since the 1950s with higher density differentials. In their work, they identify three types of urban agglomerations: southern cities, which are very compact in structure and densely populated, northern cities, which have low densities and discontinuous residential structures and, finally, western cities, which are at an intermediate level. However, research investigating the relationship between population density and municipal expenditure in this perspective is still limited [72,73] and requires additional evidence with a comparative background in homogeneous world regions, e.g., in Europe.

Capello and Camagni [74] extensively debated the concept of 'optimal size' for administrative local units, focusing on the notion of the 'efficient size' of a municipality or a city, based on the functional characteristics of the given spatial unit, and on the spatial organization within the urban system. We assume this perspective in our study, discussing how the continuous transformation of regional economic structures with intense population mobility (e.g., within metropolitan regions)—possibly reflected in multiple, subsequent reforms of local authorities (e.g., increasing or reducing the number and size of municipalities)—represents a specific condition under which we can evaluate, at least indirectly, the controversial question of scale (and agglomeration) economies in local government [74].

3. Methodology

3.1. Study Area

The Athens Metropolitan Region extends more than 3000 km^2 in the administrative region of Attica, Central Greece, and coincides with the functional boundaries of the 'Urban Atlas' region of Athens, representing the capital city and the main historical center of the Greek Republic since its constitution. All mainland municipalities, including those belonging to Salamina island, close to Piraeus harbor, are considered in the study area (Figure 2). While the regional territory mostly consists of mountains bordering the flat area around Athens, three coastal plains (Messoghia, Marathona, and Thriasio) concentrated population commute to the Athens–Piraeus' conurbation [75]. Our analysis covers a time frame of more than 80 years between 1928 and 2012, covering sequential expansion waves characteristic of the Athens' metropolitan cycle [76], mixing urbanization and suburbanization with counter-urbanization and reurbanization stages [45]. These stages included, but are not limited to, increasing population flows from Asia Minor in the early 1920s [44], rural–urban (internal) migration as a consequence of World War II and the Civil War [77], an intense natural increase of population driven by the growing fertility and rising life expectancy in the 1960s and the 1970s [76], as well as increasing migration flows (both internal and international) in more recent decades [78].

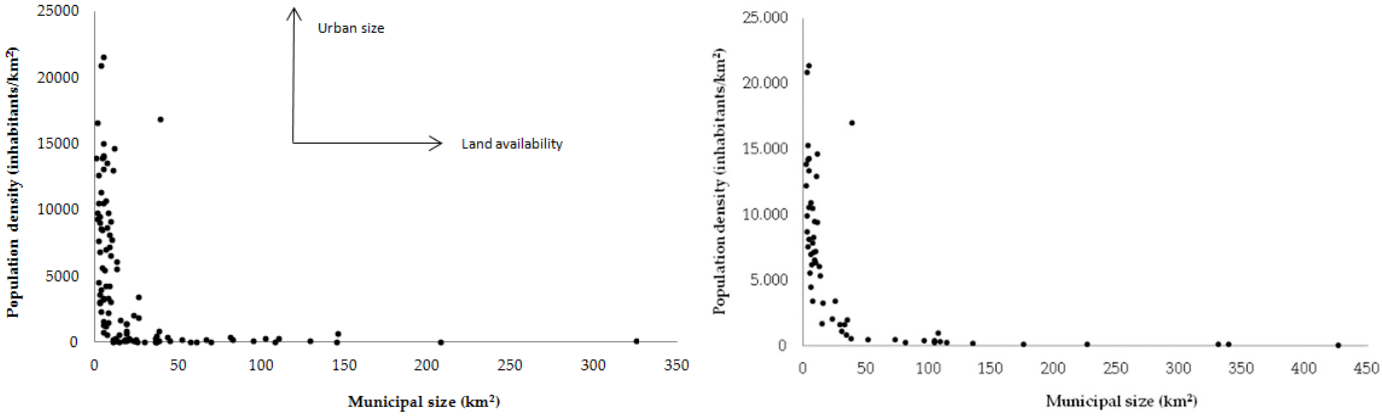

Figure 2. Scatterplots illustrating the relationship between population density and municipal size (left: 'Kapodistrias' spatial organization; right: 'Kallikratis' reform of local authorities) in the study area (2011 population), evidencing agglomeration (urban size, *y*-axis) and rural dimension (land availability, *x*-axis).

3.2. Logical Framework

In this study, we took Greek municipalities as a basic governance entity with administrative autonomy and devoted to the general interest of local populations [79]. The capital city (Athens) is governed by a municipal council whose boundaries of influence include the settlements with the highest population density in the whole region. In addition to municipalities, metropolitan areas bring together several municipalities into districts with a coherent policy framework. In Greece, a metropolitan area defines an agglomeration (or conurbation) which, for its various services and activities, depends on the central city (in this case, Athens) and is characterized by upper economic functions and intense relationships with the surrounding territories as far as industrial productions, services, and cultural heritage are concerned (Figure 3). An articulated transport network connecting suburban neighborhoods with core settlements and consolidated social interactions between urban and rural districts also characterized the metropolitan region under investigation. The specific duties and formal attributions of Greek municipalities were discussed in [80] and they appear, in some ways, similar to the administrative characteristics of their local counterparts in other Mediterranean countries, such as Italy or Spain. In this perspective,

our results can be generalized to a broader socioeconomic and territorial context possibly referring to Southern Europe.

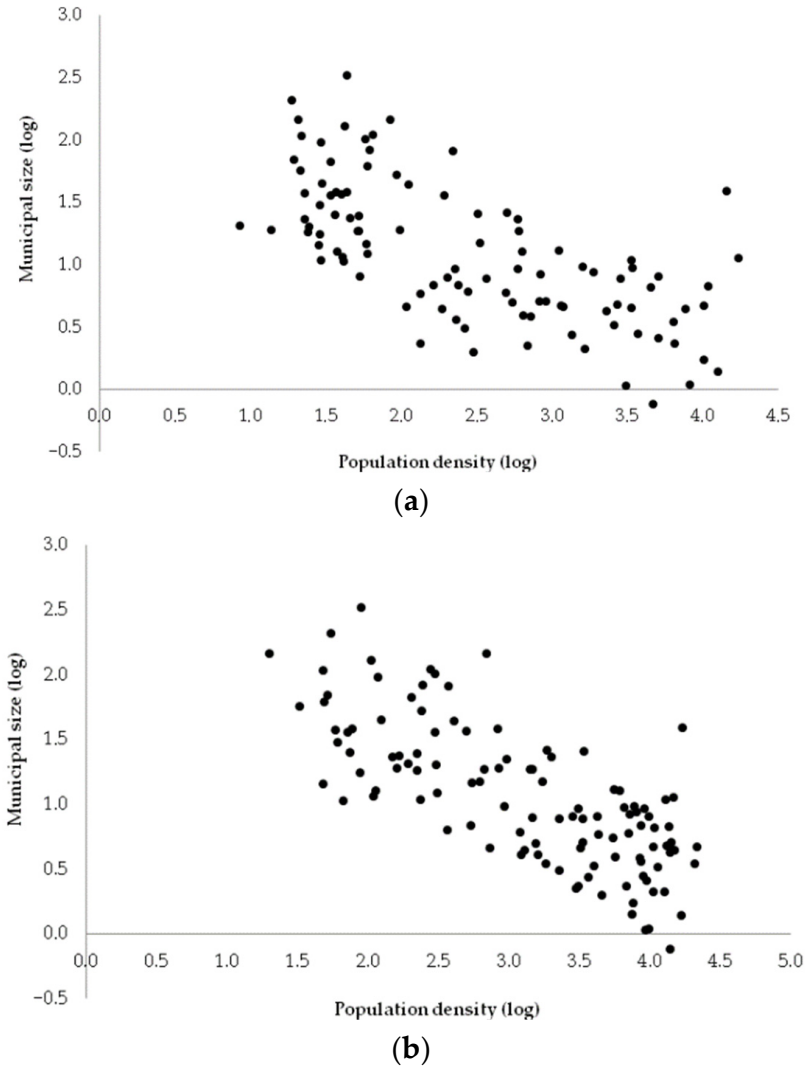

Figure 3. A log–log scatterplot illustrating the relationship between municipal area ('Kapodistrias' spatial asset) and population density for (**a**) 1951, and (**b**) 2011, in the study area (Athens' metropolitan region, Greece).

From an operational point of view, we introduce and analyze two quasi-experiments in terms of municipal restructuring under heterogeneous conditions of population growth, urban change, and socioeconomic dynamics [81–83]: (i) the progressive increase in the number of municipal units under the same general spatial framework (based on the traditional spatial asset of municipalities in Greece, consolidated with the more recent 'Kapodistrias' organizational structure); this structure was adapted to manage intense population growth and massive urban expansion into rural areas (between 1928 and 2011) within a unique metropolitan region (Athens), and resulted in a partition of the study region into more than 100 administrative domains; and (ii) a more recent reform of local government units (2011), the so-called 'Kallikratis' law approved by the Greek parliament reducing the number of municipalities to nearly 60 in the study area [77,84–86] as a basic measure of a broader 'spending review' in a long period of austerity after the 2007 recession.

3.3. Data Sources and Elementary Variables

The municipal area (km^2) and population size (total resident inhabitants) were derived from general population censuses held by the National Statistical Service of Greece (NSSG, now ELSTAT) approximately every 10 years (1928, 1940, 1951, 1961, 1971, 1981, 1991, 2001, 2011, and 2021). These data were used to calculate population density per municipality (inhabitants/km^2). The surface area of existing municipalities at each date was also derived from territorial statistics of NSSG/ELSTAT [45]. A vector map of municipalities provided by ELSTAT was used to illustrate the spatial distribution of the investigated variables over time [75]. A scatterplot was also drawn to illustrate the relationship between population density and municipal size (Figure 1), evidencing a logarithmic form that distinguishes 'urban' municipalities (administering a comparatively small area with remarkable population density) from 'rural' municipalities (with larger area and lower density). Such territorial distinctions incorporate the basic definition of municipalities adopted in the Greek population census and homogenized at the continental scale by Eurostat. Descriptive statistics, (parametric and nonparametric) correlation analysis, and simplified econometric models using linear specification, were run with the final aim of evaluating the evolution of the relationship between population density and municipal size over time [44]. In addition to positive issues (e.g., corroborating earlier theories or opening new research perspectives), results of the quantitative analysis may inform political and planning adjustments toward a more balanced spatial distribution of population and land among local government units [87].

3.4. Statistical Analysis

Assuming municipal size is negatively correlated with population density, the present study proposes a quantitative approach evaluating the inherent implications in this relationship, e.g., in terms of optimal municipal size, using homogeneous, time-series population data covering a sufficiently long time interval between 1928 and 2021. A preliminary analysis was run using both parametric (Pearson coefficient) and nonparametric (Spearman and Kendall coefficients) approaches [88], where the three correlation coefficients were tested with the final objective of identifying both linear and nonlinear relationships between population density and municipal size [89]. Similar values in the three correlation coefficients indicate a linear relationship between variables [90].

Focusing on the logarithmic transformation of both population density and municipal size values in the study area, a linear specification was considered when testing against a possible 'regime shift' over time [91]. Based on these assumptions, a linear regression model was run using log (municipal size) as a dependent variable and log (population density) as a predictor separately for each study year (from 1928 to 2021). Slope coefficients and intercepts estimated through an ordinary least squares (OLS) procedure, together with the respective adjusted R^2, were analyzed as the model's output [92]. The absolute ratio of coefficient slope to regression intercept was computed for each time point with the aim of evaluating changes over time in the spatial structure of the relationship between the two variables [93]. For two selected years (1928 and 2011) based on the traditional spatial asset of local units, different polynomial models (second order to sixth order) regressing log (municipal size) to log (population density) were run with the final objective of verifying if a linear form is the best descriptor of the relationship mentioned above. The percent gain in the goodness-of-fit R^2 with rising polynomial order (e.g., from order one (linear form) to order six) was calculated comparing the results of regressions that specifically refer to 1951 and 2011.

4. Results

The number of municipalities increased slightly in the Athens' metropolitan region during the study period (Table 1). Based on the traditional spatial asset of local governance units, the median size of municipalities decreased moderately from 13 km^2 to 9.5 km^2, with variability rising evidently over space. The total population (median by municipality)

increased over time because of continuous urban growth in the study area, with a coherent decrease of the spatial variability of resident population.

Table 1. Municipal size, absolute population, and population density in the Athens' metropolitan region by year, 1928–2021 (statistical figures include median and CV, Coefficient of variation; italics indicate a time point referring to the 'Kallikratis' spatial asset).

Year	Number of Municipalities	Municipal Size (km^2)		Population (Inhabitants)		Population Density (Inhabitants/km^2)	
		Median	CV	Median	CV	Median	CV
1928	96	13.4	1.5	1313	4.5	57	2.9
1940	103	12.0	1.6	2231	4.1	140	2.2
1951	105	10.7	1.6	3305	4.0	214	2.0
1961	109	10.5	1.6	5503	3.4	331	1.7
1971	112	9.8	1.6	7812	3.4	544	1.5
1981	115	9.5	1.6	10,100	2.9	637	1.4
1991	115	9.5	1.6	12,023	2.5	1235	1.3
2001	115	9.5	1.6	13,921	2.3	1401	1.3
2011	115	9.5	1.6	16,002	2.0	1717	1.2
2012	*59*	*11.2*	*1.7*	*46,897*	*1.3*	*6072*	*0.9*
2021	*59*	*11.2*	*1.7*	*46,782*	*1.3*	*6011*	*0.9*

Since 2012, the 'Kallikratis' spatial asset of local authorities resulted in a consolidation of earlier trends in the municipal area and population distribution, with larger municipal sizes (11.2 km^2) and resident populations (median per municipality) three-times higher than the precedent spatial asset. The empirical relationship between log (municipal size) and log (population density) in the Athens' metropolitan region is illustrated in Figure 3 for the first and the last points in time considered in this study, using the same spatial asset ('Kapodistrias' municipalities). The relationship was strictly linear at the end of the study period (2011) and more scattered at the beginning of the study period (1951), despite maintaining a substantial linearity throughout the study period.

Table 2 reports the main results of a correlation analysis between log (municipal area) and log (population density) or log (population stock) based on three (parametric and nonparametric) correlation coefficients. As far as population stock is concerned, all coefficients were statistically insignificant ($p > 0.05$) for all investigated years and correlation techniques, possibly indicating a substantial independence between population size and municipal size. Concerning population density, all coefficients were characterized by a comparable pattern, increasing over time to a peak observed at the end of the study period. All correlation coefficients were negative and significant at $p < 0.001$.

Regressions indicate an increasing goodness-of-fit of the linear model predicting municipal area on the base of population density (Table 3). Adjusted R^2 increased over time from 0.25 to 0.87; however, this increase followed a U-shaped pattern with the lowest value observed for 1971, in parallel with long-term urban concentration dynamics [94]. In fact, consensus exist in dating the peak of urban concentration in Athens around the first years of the 1970s [44]. Results of the 'slope-to-intercept' ratio also indicated a substantial breakpoint in the investigated time series during the 1970s, corroborating in some ways the results presented above. Regression results referring to the new spatial asset ('Kallikratis') were in line with earlier evidence, indicating a substantial consolidation of earlier trends in both slope and intercept regression coefficients. For instance, the rapid (negative) increase of slope coefficients observed for 'Kallikratis' assets stopped in 1981, decreasing in the following decades and reflecting a decentralized metropolitan growth typical of contemporary Attica [45].

Table 2. Correlation analysis (left) between municipal area (log) and absolute population (log) or population density (log) using both parametric (Bravais–Pearson moment product) and nonparametric (Spearman rank and Kendall cograduation) coefficients by year, 1928–2021. Italics refer to a time point referring to the 'Kallikratis' spatial asset, the most recent 'Kallikratis' spatial asset enforced in law since 2012; * indicates significant correlation at $p < 0.05$ after Bonferroni correction for multiple comparisons.

Year	Absolute Population			Population Density		
	Pearson	Spearman	Kendall	Pearson	Spearman	Kendall
1928	0.11	0.16	0.13	−0.59 *	−0.54 *	−0.37 *
1940	0.02	0.03	0.03	−0.66 *	−0.66 *	−0.46 *
1951	−0.09	−0.12	−0.06	−0.69 *	−0.71 *	−0.50 *
1961	−0.20	−0.20	−0.11	−0.73 *	−0.69 *	−0.49 *
1971	−0.25	−0.22	−0.11	−0.73 *	−0.69 *	−0.48 *
1981	−0.26	−0.22	−0.12	−0.75 *	−0.69 *	−0.48 *
1991	−0.22	−0.21	−0.11	−0.75 *	−0.73 *	−0.51 *
2001	−0.20	−0.17	−0.09	−0.77 *	−0.74 *	−0.53 *
2011	−0.19	−0.16	−0.08	−0.77 *	−0.74 *	−0.52 *
2012	*−0.25*	*−0.23*	*−0.14*	*−0.94 **	*−0.85 **	*−0.71 **
2021	*−0.26*	*−0.23*	*−0.14*	*−0.95 **	*−0.86 **	*−0.71 **

Table 3. Results of a linear regression (right) with municipal area (log) as a dependent variable and population density (log) as a predictor in the Athens' metropolitan region by year, 1928–2021 (d.f., degrees of freedom of the F-statistic testing for significant, nonzero goodness-of-fit, i.e., R^2; Durbin-W., Durbin–Watson statistic; intercept's and slope's errors in brackets; significant coefficient at * $p < 0.05$ or ** $p < 0.001$; italics indicate data referring to the more recent 'Kallikratis' spatial asset enforced in law since 2012).

Year	Intercept	Slope	Slope/Intercept	Adjusted R^2	df	Durbin–Watson
1928	1.83(0.13)	−0.34(0.06)	−0.18	0.25 *	1;94	1.62
1940	2.06(0.13)	−0.41(0.05)	−0.20	0.37 **	1;101	1.63
1951	2.14(0.12)	−0.42(0.04)	−0.20	0.46 **	1;103	1.63
1961	2.12(0.11)	−0.40(0.04)	−0.19	0.46 **	1;107	1.57
1971	2.14(0.11)	−0.39(0.04)	−0.18	0.47 **	1;110	1.52
1981	2.22(0.12)	−0.40(0.04)	−0.18	0.48 **	1;113	1.50
1991	2.42(0.12)	−0.45(0.04)	−0.19	0.53 **	1;113	1.61
2001	2.56(0.13)	−0.49(0.04)	−0.19	0.55 **	1;113	1.66
2011	2.60(0.13)	−0.49(0.04)	−0.19	0.56 **	1;113	1.70
2012	*3.98(0.14)*	*−0.79(0.04)*	*−0.20*	*0.87 **	*1;57*	*1.70*
2021	*3.97(0.13)*	*−0.78(0.04)*	*−0.20*	*0.88 **	*1;57*	*1.71*

Table 4 reports the percent improvement in goodness-of-fit (based on the adjusted R^2 coefficient) of models predicting municipal size from population density that use polynomial functions of increasing order (from two to six). Percent improvement in the R^2 goodness-of-fit using different polynomial models was calculated separately for two selected years (1951 and 2011) based on the same spatial asset of local municipalities. This time period was considered rather homogeneous in term of mechanisms of urban growth and spatial structures. Although modest increases were observed for both years, thus validating a linear form between municipal size and population density in the study area, the R^2 percent improvement was systematically higher for all polynomial grades when applied to 1951 data than for 2011 data. This evidence is in line with the descriptive analysis illustrated in Figure 3, outlining a less scattered distribution of observations in 2011 than in 1951.

Table 4. Percent gain in the adjusted R^2 coefficient (indicating goodness-of-fit) of the relationship between municipal area and population density moving toward specifications of increasing polynomial order on the basis of 'Kapodistrias' spatial assets of local units (n = 115), and selected years (1951, 2011) based on comparable data.

Specification (Polynomial Order)	1951	2011
2 (quadratic) vs. 1 (linear)	5.1	0.2
3 (cubic) vs. 2 (quadratic)	4.4	1.4
4 vs. 3 (cubic)	0.2	1.6
5 vs. 4	3.6	0.5
6 vs. 5	0.8	0.1

5. Discussion

Based on the inherent evolution of agglomeration economies, recent spatial changes in population structures reflect distinctive urbanization processes occurring in several European large- and medium-size cities, and causing a spatial (re)balancing of activities and population deconcentration [71,95–97], with implications for the spatial distribution and size of local administrative units, especially municipalities intended as the smaller tie of governance in the Northern Mediterranean countries. By investigating the latent relationship between population density and municipal areas in a European metropolitan region extending largely throughout the last century [98–101], our study has contributed to a multicriteria assessment of municipal distribution and size in terms of both area and resident populations [40,42,102].

Assuming the relationship between municipal size and population density is functionally related to population concentration and land availability for building [57,103,104], empirical results presented in this paper suggest that municipal size has progressively adjusted to population density, creating a more balanced spatial asset in the most recent decades [105]. Urban concentrations typical of the 1970s in the study area were likely the economic process that contributed the most to both spatial variability and heterogeneity in the relationship between municipal size and population density [75,94], possibly influencing the estimation of an 'optimal' size for administrative local units based on extant criteria that reflect, for example, population concentration [98].

Transformations in municipal boundaries with the creation (or suppression) of new administrative units may reflect a progressive change toward a more balanced population distribution over space [106]. In the study area, the municipal size decreased moderately over time with a slight increase in spatial heterogeneity; conversely, the average population density per municipality increased more rapidly with an evident reduction in spatial heterogeneity [94]. The linear relationship between municipal size and population density increased in both intensity and significance with time, reaching the highest values in 2011 (under the same spatial structure consolidated with the 'Kapodistrias' municipal asset); this relationship was reinforced in the following years, under the renewed 'Kallikratis' spatial asset of local government units [107].

The increase of municipal size and population concentration may lead to a reduction in local costs of providing local public services, because of scale economies which normally depend on the existence of fixed costs and technology [108]. Waste management, water distribution, sewage collection, public lighting, road maintenance, and other services of interest to local citizens can follow such a pattern [109]. Scale economies derive from rising services' demand when the total costs increase less than proportionally [110]. In other words, a growth in public services has a strong impact on total costs at low-levels of demand and above a certain threshold level, it has a smaller additional effect on the above total costs [111].

Even an increase in the population density can lead to a decrease in total costs, as documented by Ohlsson [112], and to (mostly unpredictable) interaction effects between scale economies and 'economies of density' [113]. In fact, the effect of scale economies seems to be even more advantageous in high-density population municipalities verifying

a stronger cost–benefit interplay [39]. Conversely, for territories with low population densities, the relationship between service demand and total costs seems to be relatively moderate [114]. The impact of specific contextual factors (e.g., population density) may reveal how some territories can be more economically sustainable and thus more attractive for entities that offer the above-mentioned services than other territories [115]. In areas with low population density there are no opportunities to realize such types of economies and, therefore, governments should support economically the entities that are heavily penalized by such contextual conditions [115].

Taken together, these conditions represent a base for the informed analysis of the spatial structure of local administrative units and a contribution to the estimation of optimal municipal size [31,63,116]. In line with earlier studies [94,117,118], our study demonstrates how a quantitative analysis of the relationship between population density and municipal area based on descriptive statistics, correlation analysis, and regression models, provides basic knowledge for identification of political and planning targets that involve a more balanced spatial distribution of population and land among local government units [53,119,120]. Based on these empirical findings, the 'optimal municipal size' can be regarded as a nonlinear and evolving notion based on the intimate dynamics of the regional system under investigation. Use of dynamic criteria to determine optimal municipal size over time and space is relevant in rapidly expanding metropolitan regions and, more generally, in economically dynamic contexts with high residential mobility and relocation of activities into wider areas.

Results of our study provide some practical suggestions for a refined assessment of municipal size and citizens' satisfaction based on distinctive approaches (e.g., the reform theory or the political economy theory), that postulate contradictory effects of government size on citizens' satisfaction with urban services. According to Mouritzen [116], "the former asserts that citizens' satisfaction increases with increasing size of urban governments because large units are more efficient and allows citizens to participate effectively in public policy making. The latter postulates that citizens are more satisfied in the smaller jurisdictions because small units are more homogeneous, efficient and democratic". A more comprehensive understanding of the intrinsic performance of local administrative units (namely municipalities) of different sizes according to the level of citizen satisfaction definitely leads to more favorable evaluations of public services [121–124].

Policy implications of the empirical analysis presented in this work are grounded in the mutual interaction between population distribution, urban concentration, and municipal size, with a specific focus on expanding metropolitan regions [125]. In line with the empirical findings of our work, further studies matching novel methodological frameworks and technical improvements in measurement and official statistics, are especially necessary to demonstrate the role of economic and social structural adjustment strategies fostering economic and social development at the local level [126–128]. In this perspective, council size and regional location are important factors of overall development not only in light of economic performance but also in terms of environmental sustainability, as rapidly growing literature shows [60].

In line with this perspective, the analysis proposed here was based on homogeneous indicators derived from official statistics over a long time interval and from rather simplified statistical techniques [38,92,129], whose results provide a knowledge base for improved policies of local development and a more sustainable (e.g., spatially balanced) organization of metropolitan regions and districts as far as local administrative units are concerned. Empirical evidence in this study suggests that a stronger integration between demographic, economic, and political indicators is required to achieve a more comprehensive picture of municipalities based on an enhanced knowledge of the socioeconomic context differing among local communities [14,18,130,131]. Further investigation is required to shed light on the intimate relationship between the changing spatial asset of local governance and the underlying socioeconomic transformations in complex and fragmented metropolitan systems.

6. Conclusions

Both changes in municipal boundaries and creation (or suppression) of new administrative units reflect a progressive alteration toward a more balanced population distribution over space. Municipal size is a key variable delineating the amount and spatial concentration of services and infrastructures, being functionally related with population density, agglomeration factors, land availability for building, and a characteristic profile of local communities in expanding metropolitan regions. The long-term socioeconomic context (1928–2021) reflecting urban expansion, population dynamics, and municipal size in the study area was explored through a statistical analysis of the relationship between population density and municipal area; results of this analysis provide basic knowledge to policy and planning adjustments toward a more balanced spatial distribution of population and land among local government units. The empirical findings indicate that the average municipal area in Athens decreased moderately over time with a slight increase in spatial heterogeneity. Conversely, the average population density per municipality increased more rapidly with a marked reduction in spatial heterogeneity. Evidence also suggests that municipal size has increasingly adjusted to population density across metropolitan regions, determining a more balanced spatial distribution of resident populations. Such conditions provide a preliminary knowledge of spatially explicit analyses of local administrative units and justify an enriched discussion on the notion of optimal municipal size and the geographic arrangement of administrative urban districts.

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